Manufacturing Questions Program Managers Should Ask

PMSC — Meeting the Needs of ACAT III Program Managers

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The Acquisition Management Functional Board approved establishment of an assignment-specific course for Acquisition Category III (ACAT III) program managers/deputy program managers (PM/DPM), called the Program Managers Survival Course (PMSC). The College created and structured the course to meet the special needs of ACAT III PMs, which include a different set of leadership and managerial challenges, and less depth of support than normally given to ACAT I and II PMs. One of the areas covered in this two-week survival skills course is manufacturing management. This first article in a series will discuss several design tools available to bring manufacturing considerations into the design process earlier, and risk reduction through the application of a quality system. Future articles will address other manufacturing topics of interest to the PM.

What is Manufacturing?

The term "manufacturing" covers a broad set of functional tasks required to harness all the elements needed to make a product. Included are such wide-ranging topics as the National Technology and Industrial Base (NTIB) capabilities to support the program, influencing the design for cost effective manufacturing, the people and skills needed, the selection of materials, appropriate methods of production, capable machinery, scheduling, measurements, and quality assurance management systems. Manufacturing requires the support of functional specialties from a diverse set of organizations, including matrix-assigned manufacturing managers, other program office functionals, con-

PROGRAM MANAGERS SURVIVAL COURSE DIRECTOR MICHAEL MEARS HOLDS A ROUNDTABLE DISCUSSION WITH THE CLASS ON OVERALL COURSE CONTENT. STANDING FROM LEFT: CURTIS HAROLD, U.S. ARMY CIVILIAN; LT. COL. JOHN DEACON, USA; LT. COL. TIM MCKAIG, USA; LT. COL. PAT LINEHAN, USA; LT. COL EARL SUTTON, USA; SHARON DAVIE, U.S. ARMY CIVILIAN; COL. TOM SHIVELY, USAF; LT. COL. MIKE REED, USAF. SEATED FROM LEFT: CYNTHIA MOONEY, U.S. ARMY CIVILIAN; LT. COL. CHARLES MCMASTER, USA; CHARLIE CARPENTER, U.S. AIR FORCE CIVILIAN; MARK TORMEY, U.S. ARMY CIVILIAN; COL. DEAN NAKAGAWA, USA.

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Photos by Richard Mattox

tract administration services personnel, laboratories, contractors, and commodity staffs as well as depot personnel.

Historically, 30 percent of a program's total costs are consumed by production activities. Moreover, this significant investment is spent within a relatively short amount of time. Additionally, transitioning a system from development to production has also historically proven difficult, with attendant cost penalties. A Defense Science Board study reveals that 30 percent of our production costs are non-value added (a.k.a. cost of quality, or the Hidden Factory).

ON THE LAST DAY OF THE PROGRAM MANAGERS SURVIVAL COURSE, MAY 3, 1996, COURSE DIRECTOR MICHAEL MEARS, PROFESSOR OF ENGINEERING MANAGEMENT, SCHOOL OF PROGRAM MANAGEMENT DIVISION, DSMC, PRESENTS STUDENTS A FINAL REVIEW. PICTURED FROM LEFT: MEARS; LT. COL. CHARLES MCMASTER, USA; SHARON DAVIE, U.S. ARMY CIVILIAN.

More simplified contracting actions, increased reliance on commercial specifications and standards, and less functional support bring significant opportunities to better integrate the NTIB and make more of it available to meet DoD requirements.

What's New?

Today's acquisition realities offer new opportunities to reduce program risks, but they also pose some new challenges to program managers. From a manufacturing perspective, there are three important trends: DoD downsizing, acquisition reform, and technology improvements. Reduced requirements equate to fewer production programs and severe reductions in those programs that do go forward. The effect is a potential loss in critical skills required of design teams in terms of designing for production, and less experience for production planning, scheduling, and controlling. Additionally, longer service lives and purchasing commercial off-the-shelf and nondevelopmental items as a policy initiative will mean more ACAT III programs with unique risks accompanied by the challenges of reduced functional support and smaller staffs.

Acquisition reform also brings new opportunities and challenges to the PM world. More simplified contracting actions, increased reliance on commercial specifications and standards, and less functional support bring significant opportunities to better integrate the NTIB and make more of it available to meet DoD requirements. This adds other unique challenges: What is a "Best Commercial Practice"? How good is it? Will the contractor's system meet my risk management needs?

Advances in information technology now enable the implementation of manufacturing management techniques in an affordable and effective manner. Some of the tools described in the following paragraphs (e.g., design of experiments) and producibility engineering and planning are easier to do with today's computers and software. Their widespread use can significantly reduce program risks.

DSMC Manufacturing Management Curriculum

We believe 80 percent of a manufacturing functional's job is influencing the design and getting ready for production; toward that end, all of our curriculum is designed to convey current DoD policies, regulations, and management tools related to manufacturing in defense acquisition. This philosophy is equally valuable in the two-week PMSC. Throughout the duration of the course, students will receive updates on the latest policies and initiatives impacting the manufacturing function. Additionally, students will be exposed to "Best Practices" being employed by world-class producers in both the defense and commercial facilities of the NTIB. Based on this material, we developed a set of questions any PM may want to ask of either the manufacturing functional or the development contractor.

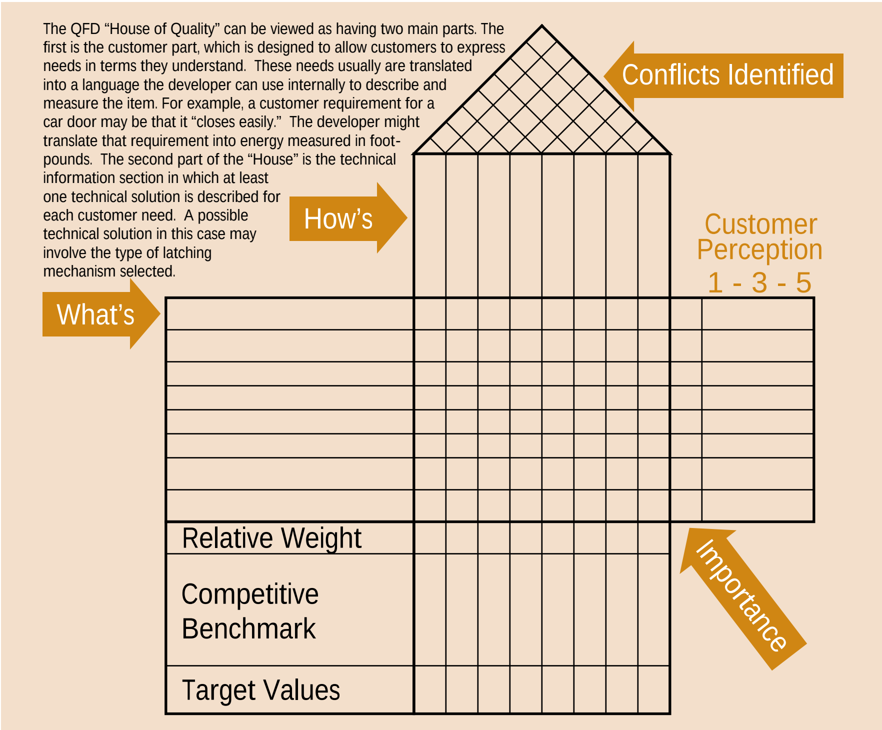

Figure 1. House of Quality

Development Tools

As mentioned previously, we put a great deal of emphasis on the importance of influencing the design process for manufacturability. One way to do that is to implement Integrated Process and Product Development (IPPD), using Integrated Product Teams, or IPTs. Through the use of teams populated with appropriate functional area representatives who can concurrently perform required acquisition activities, IPPD attempts to optimize the development, production, and support processes.[1] The goal of IPTs is to make timely team decisions based on input from all functional areas (e.g., program management, engineering, and manufacturing), including customers and suppliers.

Currently, IPPD is working in the commercial marketplace as well as in the defense industry. At Chrysler, IPTs are called platform teams, and were used to develop the LH (mid-sized sedans) platform. Chrysler needed only 39 months versus the previous 54-month time frame for developing and launching the cars. The company used 740 engineers to work on the LH cars, compared to the 2000 used on earlier platforms. The factory employees that produced the LH cars numbered just 3000 employees for full two-shift production, whereas earlier platforms needed as many as 5,300.[2]

Smart Questions to Ask

The first logical question to ask is, *"What engineering design tools used during development integrate manufacturing processes and affordability into the design?"*

Quality Function Deployment (QFD). Programs in development face many risk drivers to cost, performance, and schedule. One of those drivers is customer requirements, especially when those requirements keep changing, are soft, or are not fully or adequately developed. A core development task is the gathering of requirements and the translation of these requirements into technical solutions.[3] As a planning process, QFD uses multifunctional teams to get the voice of the customer into the design specifications. User requirements and preferences are defined and categorized as user attributes, which are then weighted based on importance to the user. Users are then asked to compare how their requirements are being met now by a fielded weapon system (or an alternative design approach) versus the new design. As a result, QFD provides the design team an understanding of customer desires (in clear text language), forces the customer to prioritize those desires, and compares/benchmarks one design approach against another. Each customer attribute is then satisfied by at least one technical solution. Values for those technical solutions are determined, and again rated among competing designs.

Finally, the technical solutions are evaluated against each other to identify conflicts. A convenient form for viewing the ultimate product is the "house of quality" (Figure 1), which should help the design team translate customer attribute information into firm operating or engineering goals, and identify key manufacturing characteristics.

Design for "X". The term "DFX" refers to a series of design approaches to achieve specific design-build objectives. Included in DFX are examples such as Design for Manufacture and Assembly (DFMA) and Design for Recycling (DFR). The first example, DFMA, focuses specifically on defining product design options for ease of fabrication and assembly. The goal is to integrate the manufacturing engineer's knowledge of the factory floor (i.e., manufacturing processes), along with the use of design principles and rules, to develop a more producible product. Examples of the design rules include minimizing part count, using standard components, designing parts for ease of fabrication, and avoiding separate fasteners. Also, DFMA can provide secondary benefits by increasing reliability, reducing inventory, and shortening product development cycle time. The second example, DFR, focuses specifically on achieving an optimization of recycling and reuse of materials at the end of a product's life cycle.

Design of Experiments (DOE). Many factors affect the quality of the end item. If our goal is to design and build quality into our products, we must control those factors that have the greatest impact on fit, performance, and service life. Most experimentation done today on the factory floor occurs by accident; i.e., manufacturing personnel first turn one knob (speed) up, and another knob (temperature) down in an attempt to bring product quality in line with specification requirements. They often change several factors at the same time and fail to collect or analyze data. They are not documenting and understanding the process; they are merely tampering with the system. Therein lies the benefit of DOE, which provides a structured way to characterize processes. A multifunctional team analyzes a process and identifies key characteristics, or factors that most impact the quality of the end item. Using DOE, the team runs a limited number of tests, and data are collected and analyzed. The results will indicate which factors contribute the most to end item quality, and will also define the parameter settings for those factors. Now, rather than tweaking or tampering with the system, production managers have the profound knowledge of their factory floor processes, which allow them to build quality in, starting at the earliest stages of design.

How will management determine that equitable requirements tradeoffs are made between design and manufacturing processes during development?

The answer to this question will vary based on the phase of the acquisition program. At Preliminary Design Review for instance, our contractor should provide evidence of performing producibility analyses on development hardware trading-off design requirements against manufacturing risk, cost, production volume, and existing capability/availability. Production planning demos should address material and component selection, preliminary production sequencing methods and flows concepts, new processes, manufacturing risk, facility/equipment usage for intended rates and quantities, and acceptance test and inspection concepts.

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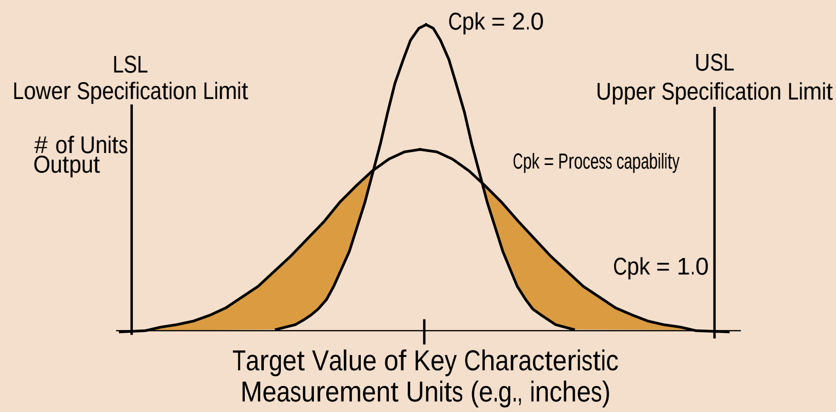
Cost as an independent variable requires increased focus on cost as an input to the design process. Design-to-cost goals should be established with the help of the manufacturing IPT. For example, an air superiority fighter program has a design-to-cost goal based on previous fighter programs, where 32 percent of life cycle costs are consumed in production. The manufacturing IPT's goal would be to reduce that number by some portion (e.g., 4 percent) while not penalizing Operations and Support or Research and Development costs.

Of those manufacturing processes which do not exist or are unproved, what is planned to prove them out?

The primary way of doing this is by comparing program needs to work being done under the DoD's Manufacturing Science and Technology Program. The objective of this program is to develop or improve manufacturing processes, techniques, materials, and equipment to provide timely, reliable, and economical production of defense systems. Another way is to monitor



Variation is the silent killer on the factory floor, because it can significantly impact product quality. Process capability (Cpk) is a unit-less measure of product quality based on the nominal or target value. (Note: Process capability calculations can be made for other than normal distributions.)

Both processes are within specification limits. But minimizing variation, especially for key characteristics, is usually beneficial. Problems that occur with products falling in the cross-hatched areas include: degraded performance, increased support costs, and higher product rework rates.

Figure 2. Reducing Variation

service laboratories' technology investment plans and technology area planning. In either case, the goal is to ensure advanced manufacturing technologies are being considered by the contractor, the government, preferably both. As advanced technologies are integrated into manufacturing planning, process proofing should be demonstrated in a factory representative environment before rate production begins.

Quality Systems

As noted previously, DoD has relied in the past on specifications and standards to promote competition and to ensure high quality products or processes. Specifications and standards were easy to use and put on contract, and also eased the source selection process because buyers (especially for numerous low-cost, commercially available items) could focus on cost versus quality. With today's emphasis on performance specifications and commercial standards, the PM's best way to influence product quality is through implementation of a quality system.

How does the contractor plan to implement process control?

Implementation of a quality system is the best way to control processes. Elements of a basic quality system (e.g., ISO 9000) that contribute to process control include corrective and preventive actions, training, calibration of measurement and test equipment, nonconforming product control, control of purchased materials and components, use of statistical techniques, and use of internal audits.

I want to go beyond ISO 9000 to manage the risk on my program. What advanced quality concepts should I pursue?

Many of the tools and techniques already addressed would contribute to advanced quality. Another is the concept of Key Product Characteristics (KPC). Identifying KPCs and their design limits, followed by identification of key production processes and their capabilities are engineering tasks that support manufacturing development. The intent is to: identify design characteristics that most influence performance, supportability, and cost (see the QFD discussion above); determine and verify the capability of the production processes that effectively and affordably meet the mission requirements; and develop production process control techniques.

Product variation is the silent killer on the factory floor. As KPCs vary from nominal, losses occur usually in the form of scrap, rework, or repair; if products are fielded, then losses include degraded performance, lower reliability, and increased support costs, or upset customers. Once KPCs are identified, associated key processes can be evaluated for affordable maximization of process capability or Cpk (Figure 2). This implies further that a Process Control Plan be developed which ensures that required product quality is achieved at the lowest possible cost. Process Control Plans include the use of process control charts, statistical process control to differentiate common from special causes of variation, and gauge variation studies to minimize errors in measurement.

How will development hardware be used to demonstrate fabrication, assembly, test and production processes?

Development hardware, while usually used to examine initial compliance with specifications, should also be used to demonstrate manufacturing processes. At this stage in the acquisition life cycle (typically Product Definition and Risk Reduction or early Engineering and Manufacturing Development Phase), manufacturing processes can be characterized as:

- **Existing and Capable**. Indicates little work is needed since quality requirements can be met by current manufacturing techniques.
- **Existing But Not Capable**. Indicates the manufacturing process may be known, but not fully capable of meeting program rate, quality, or performance goals. This presents risk to the program; a plan needs to be developed to mature this technology, find a suitable alternative, or perhaps both.
- **Nonexistent**. Development hardware was produced using techniques not transferable to the factory floor. This presents significant risk to the program; a plan needs to be developed to develop this technology, find a suitable alternative, or perhaps both.

How can continuous process improvement be incentivized?

One way is to use award fees based on reductions in the variance of KPCs, i.e., increase Cpks, without increasing costs of the end item/component. Another method is to use award fees or a savings sharing plan based on reduction in process costs that do not sacrifice performance or schedule.

Future Installments

In this article we have looked at systemic changes in the acquisition environment that may impact defense manufacturing in particular. We started at the earliest stages of design, and described some of the tools available to the manufacturing functional to make that design more producible. In the quality section we covered some advanced quality tools, and saw again that a quality product in the end starts with the design.

In the second installment of this series, we will look at lean as well as "green" manufacturing. See you then!

ENDNOTES

1. Secretary of Defense letter, "Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition," May 10, 1995.

2. Ingrassia, Paul and Joseph B. White, "Shifting Gears," *America West Airlines Magazine*, November 1994, p.52.

3. Lang, James D. and Paul B. Hugge, "Lean Manufacturing for Lean Times," *Aerospace America*, May 1995, p.28.